MONMOUTH UNIVERSITY | SCHOOL of SCIENCE

2024
SUMMER RESEARCH PROGRAM SYMPOSIUM

August 8, 2024

Dear Friends and Colleagues,

I would like to take this opportunity to thank the supporters and university partners who contributed to the success of the 2024 Monmouth University School of Science Summer Research Program (SRP) and other summer research opportunities offered to our students. Their contributions allow us to provide research experiences for undergraduate students by funding their summer salaries as research assistants, acquisition of the supplies and equipment necessary to complete their research projects, and providing opportunities for students to travel to conferences and professional meetings to present their research. Without their collective philanthropy and support, the Summer Research Program would not be possible.

I would also like to acknowledge the faculty from the School of Science who dedicated their time and offered their expertise to mentor participating students this year.

Lastly, I offer congratulations to the student research assistants for their efforts and enthusiasm in completing their projects that are highlighted at today's Summer Research Program Symposium.

John A. Tiedemann, Assistant Dean
Monmouth University School of Science

2024 Summer Research Program
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The School of Science Summer Research Program (SRP) would not be possible without the support of the Departments of Biology, Chemistry and Physics, Computer Science and Software Engineering, and Mathematics as well as a number of other University offices, programs, and supporters including the following:

Monmouth University Office of the Provost

Monmouth University's Office of the Provost provides the chief academic leadership, responsibility and support to all of the University's schools and centers of distinction. The Provost Office provides stipends to faculty that participate as mentors to our Summer Research Program student research assistants.

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The School of Science Dean's Advisory Council provides key input to the School's strategic planning process and annual support for the Summer Research Program. Council members include:

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2024 Summer Research Program Symposium

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Science Building – Room E 201

Thursday, August 8, 2024

10:00 a.m. – 1:00 p.m.

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Symposium Agenda

10:00 a.m. – 10:15 a.m.	**Welcome** Interim Dean Joe Coyle
10:15 a.m. – 10:30 a.m.	**Opening Remarks** John Tiedemann, Assistant Dean & SRP Director
10:30 a.m. – 12:00 p.m.	**Poster Session**
12:00 p.m. – 12:15 p.m.	**Closing Remarks** Interim Dean Joe Coyle
12:15 p.m. – 1:00 p.m.	**Lunch and Networking**
1:00 p.m.	**Adjourn**

The Symposium features poster presentations highlighting research projects conducted by School of Science students who participated in the School of Science Summer Research Program

2024 Summer Research Symposium
Project Abstracts

Department of Biology

SRP – 1 **Purple Pitcher Plant Community Ecology In The New Jersey Pine Barrens**

Paul Santarsiero, Sage Phelps, and Rachel Damstra
Monmouth University Department of Biology

Faculty Mentors: Dr. Pedram Daneshgar, Dr. Kevin Dillon, and Kelly Zimmerman

SRP – 2 **What Have We Learned About The Spatial Ecology Of An Eastern Box Turtle Population After Two Years Of Study In Suburbia?**

Richard Robinson and Chris Meehan
Monmouth University Department of Biology

Faculty Mentor: Dr. Sean C. Sterrett

SRP – 3 **The Abundance And Types Of Plastics Found On Hathaway Beach In Deal, New Jersey**

Drew Mattia
Monmouth University Department of Biology

Faculty Mentor: Assistant Dean John A. Tiedemann

Department of Chemistry and Physics

SRP – 4 **Investigating Ligand-Induced Local Conformational Changes Of Fluorescently Labeled G-Quadruplex Structures**

Alexa Houseknecht and Macklin Jugan
Monmouth University Department of Chemistry and Physics

Faculty Mentor: Dr. Davis Jose

SRP – 5 **A Spectroscopic Evaluation Of The B To A Conformational Transition In Duplex DNA Using Fluorescent Base Analogues**

Samantha Lecrone and Andrea Freije
Monmouth University Department of Chemistry and Physics

Faculty Mentor: Dr. Davis Jose

SRP – 6 **Investigation Of Cell Motility Under Varying Viscosity And External Load**

Jake Barbieri[1], Jeffery Brewer[2,] and Anthony Espanol[2]
[1]University of Washington, [2]Monmouth University

Faculty Mentor: Dr. Ilyong Jung

SRP – 7 **The Catalytic Chemistry Of The I-R3 DNA Enzyme Through Ion Promoted Cleavage**

Madison Pellerito
Monmouth University Department of Chemistry and Physics

Faculty Mentor: Dr. Jonathan Ouellet

SRP – 8 **PCR Assembly Technique To Produce A Plasmid Used For Ratiometric Fluorescence Measurements**

Haniya Qureshi and Akriti Tandon
Monmouth University Department of Chemistry & Physics

Faculty Mentor: Dr. Jonathan Ouellet

Department of Computer Science and Software Engineering

SRP – 9 **Lip Synchronization Of 2D Animated Characters: A Preliminary Dataset**

Crosby Collins[1], Ethan Yung[2], Raymond Yung[3], William Judd[4], Dominick Del Bene[5], and Kelly Yuan[2]

University of Pennsylvania[1]; High Technology High School[2]; Freehold Borough High School[3]; University of Illinois Urbana-Champaign[4]; Monmouth University[5]

Faculty Mentor: Dr. Weihao Qu

SRP – 10 **Reinforcement Learning-Based Delivery Path Optimization For Hospitals**

Miriam Abecasis[1], Jason R. French[1], Kevin Yuan[2]
[1] Monmouth University; [2] University of Wisconsin-Madison

Faculty Advisor: Dr. Jiacun Wang

DEPARTMENT OF BIOLOGY

SRP-1

PURPLE PITCHER PLANT COMMUNITY ECOLOGY IN THE NEW JERSEY PINE BARRENS

Paul Santarsiero, Sage Phelps, and Rachel Damstra
Monmouth University Department of Biology

Faculty Mentors: Dr. Pedram Daneshgar, Dr. Kevin Dillon, Kelly Zimmerman
Monmouth University Department of Biology

Funding Sources:
Monmouth University School of Science; Department of Biology

Abstract

The Purple Pitcher Plant, *Sarracenia purpurea*, is a carnivorous plant native to the New Jersey Pine Barrens. This species grows in low-nutrient soil; therefore, they utilize a pitfall to trap and digest invertebrates for supplemental nutrients. The pitcher-shaped leaves collect rainwater which in turn harbor a microecosystem with various microbes and invertebrates. The plant relies on chitinase-producing bacteria to break down the chitinous exoskeletons of the invertebrates.

The objective of this research was to gather data on the plant morphology of each pitcher plant as well as the microbial and invertebrate communities over the course of a year in the New Jersey Pine Barrens. Individual measurements of each pitcher were taken and the species of bacteria and invertebrates present in each sample were identified. It was hypothesized that the bacterial and invertebrate communities will vary depending on the sampling site and time of year. It was also hypothesized that different environmental factors and plant-specific measurements could be potential predictors of associated microbial communities. As research progressed, it was seen that pitcher plants from each site had a unique community associated with them, yet there was a noticeable overlap from site to site. In order to identify individual microbes that were present, a Polymerase Chain Reaction (PCR) was performed for each genomic DNA (gDNA) sample for later DNA sequencing. Due to the longevity of this research, additional measurements will be taken in the fall of 2024, winter of 2024, as well as the spring of 2025 to account for the seasonal diversity of the species.

SRP-2

WHAT HAVE WE LEARNED ABOUT THE SPATIAL ECOLOGY OF AN EASTERN BOX TURTLE POPULATION AFTER TWO YEARS OF STUDY IN SUBURBIA?

Richard Robinson and Chris Meehan
Monmouth University Department of Biology

Faculty Mentor: Dr. Sean C. Sterrett
Monmouth University Department of Biology

Funding Sources:
Monmouth University School of Science; Department of Biology; Urban Coast Institute

Abstract

Suburban development in the eastern U.S. is replacing the natural habitat required for the survival of the Eastern Box Turtle (*Terrapene carolina*: hereafter EBT), a species in decline due to habitat loss and fragmentation, road mortality, and transmissible diseases. A typical scenario for EBT populations is that they are forced into smaller parcels of land, often surrounded by suburban development. However, there is a lack of understanding for how these populations persist, given changes in resources and connectivity of the landscape. For example, suburban EBT are expected to have reduced home ranges due to the compression of their habitat; although this has not been tested. The objective of this study was to characterize the spatial ecology of EBT populations in suburban areas when compared to EBT populations in contiguous habitats. EBT were affixed with 15-g radio transmitters within a suburbanized park in Monmouth County, New Jersey from 2022 to 2024. Bi-weekly surveys of movement data were collected for 24 EBT (12 male, 12 female) during summer months. The diverse array of habitat types within the park includes hardwood forests, pinelands, wetlands, and early successional, open fields. Data examining the habitat preferences of EBT at the park were also collected. Habitat selection data were recorded by examining environmental features surrounding EBT, such as the distance from an EBT location to a tree or a path used by humans. After the data for the area surrounding the turtle was gathered the same environmental data would be collected again at a random location to determine if the turtles were preferential in their habitat selection. Morphological data and global positioning system coordinates were recorded for turtles incidentally found within the park. In addition to radiotelemetry of a subset of individuals, a dense population was incidentally observed at the study area with 330 individuals found.

SRP-3

THE ABUNDANCE AND TYPES OF PLASTICS FOUND ON HATHAWAY BEACH IN DEAL, NEW JERSEY

Drew Mattia
Department of Biology; Marine and Environmental Biology and Policy Program

Faculty Mentor: Assistant Dean John Tiedemann
Monmouth University School of Science

Funding Sources:
Monmouth University School of Science; Department of Biology

ABSTRACT

Plastics remain one of the most prevalent forms of pollution and linger in the environment in various forms indefinitely. The rise in global plastic production in recent decades has caused an influx of plastic debris in the coastal zone. Plastics can enter the environment through a variety of sources such as stormwater, runoff, and litter. The abundance of plastics present on beaches pollutes the marine ecosystems and can be detrimental to the health of both fish and wildlife. For example, wildlife can ingest plastics or become entangled in them.

This study examined the types and quantities of plastics found on Hathaway Beach in Deal, NJ over two years. The most common types of plastics found were fragments (44%) followed by film (18%) and foam (15%).

It is important to analyze the types and abundance of plastics in the natural environment to identify potential sources and develop mitigation strategies or improve management programs to help reduce plastics in the environment and prevent further harm to fish and wildlife.

DEPARTMENT OF CHEMISTRY
AND
PHYSICS

SRP-4

INVESTIGATING LIGAND-INDUCED LOCAL CONFORMATIONAL CHANGES OF FLUORESCENTLY LABELED G-QUADRUPLEX STRUCTURES

Alexa Houseknecht and Macklin Jugan
Monmouth University Department of Chemistry and Physics

Faculty Mentor: Dr. Davis Jose
Department of Chemistry and Physics

Funding Sources:
Monmouth University School of Science; Department of Chemistry and Physics

Abstract

DNA sequences rich in guanines readily fold to form quadruplex structures (GQs), which are bound by Hoogsteen-type hydrogen bonding of four guanine nucleotides (G4). GQs are important structural components in many physiological functions, including limiting telomerase activity seen in 85-90% of human tumor cells. Telomerase activity can be influenced by introducing small molecules that can interact with GQs. This interaction of small molecules can alter the stability and local conformations of the GQ at the guanine tetrad level, which in turn can affect the telomerase activity and cancer progression. To identify changes in the local conformations of the telomeric sequence upon interaction with small organic molecules, we incorporated 6-methylisoxanthopterine (6MI), a circular dichroism (CD)-active fluorescent base analogue of guanine in place of guanine at distinct positions in the human telomeric GQ sequence. Several variations of DNA sequences were used to monitor the conformational changes at different locations of the GQ structure using UV-Vis, CD, and fluorescence spectroscopic methods. Past studies investigated the binding of TmPyP4 (5,10,15,20-Tetrakis-(N-methyl-4-pyridyl) porphyrin), a telomerase-inhibiting ligand, to the GQ but only addressed their interaction in a global conformational perspective. In this study, we used fluorescent base analogues to track the local conformation at individual G-tetrad levels using spectroscopic methods. The results demonstrated an initial stabilization followed by destabilization of the human telomeric DNA sequence with increasing ratios of TmPyP4. In contrast, the modified strands showed stabilization or destabilization depending on the position of the probe. The results suggest that site-specific fluorescent probes can monitor the global and local structure and stability changes in GQs upon ligand binding. Understanding the effect of different drugs on the local GQ conformation will help to develop targeted drugs to treat cancer and other telomere-related diseases.

SRP-5

A SPECTROSCOPIC EVALUATION OF THE B TO A CONFORMATIONAL TRANSITION IN DUPLEX DNA USING FLUORESCENT BASE ANALOGUES

Samantha Lecrone and Andrea Freije
Monmouth University Department of Chemistry and Physics

Faculty Mentor: Dr. Davis Jose
Monmouth University Department of Chemistry and Physics

Funding Sources:
Monmouth University School of Science; Department of Chemistry and Physics

Abstract

The transition of the standard B-form DNA helix to A-form DNA was first seen by X-ray imaging of DNA fibers in 1953. Over time, B and A DNA structures have been further characterized with many higher-resolution crystal structures. The transition of B-DNA double helix to A-form is essential for biological functions as recognized by the presence of A-form DNA in many protein-DNA complexes. Recently, it was proposed that the shorter length of the A-form DNA compared to the B-form DNA might play an essential role in duplex DNA packaging in bacteriophages and that this conformational change might itself serve as the source of the large forces generated by the DNA packing motors. Even though it is known that the B to A conformational transition occurs, the specifics, like where in the DNA it originates, how it propagates, and the detailed step-by-step mechanism involved, are still unknown. We explored the local and global conformational changes in this highly biologically relevant transition using site-specifically positioned fluorescent oligonucleotides. Our results showed that we could simultaneously monitor the local and global conformational change by using 2-aminopurine (2-AP), a fluorescent analogue of Adenine.

SRP-6

INVESTIGATION OF CELL MOTILITY UNDER VARYING VISCOSITY AND EXTERNAL LOAD

Jake Barbieri[1], Jeffery Brewer[2,] and Anthony Espanol[2]
[1]University of Washington, [2]Monmouth University

Faculty Mentor: Dr. Ilyong Jung
Department of Chemistry and Physics

Funding Sources:
Monmouth University School of Science; Department of Chemistry and Physics

Abstract

Motile flagella and cilia of swimming microorganisms at low *Reynolds* number have been under scrutiny due to their multi-functional roles such as sensing extracellular signals, nutrient uptake, and exerting propulsive force and torque for their locomotion.

Paramecium is a unicellular protozoan covered by thousands of cilia. It is commonly studied in biology as representative of the ciliates due to its being widespread in nature and its relatively large size. Moreover, it shows clear quantifiable responses to environmental stimuli such as gravity, viscosity, magnetic field, electric field, temperature, light, and chemical gradients. Of particular interest has been its response to gravity, called Gravikinesis, under varying viscosity that play important roles in cell life. In spite of its importance and many studies of responses to those environmental stimulations, some crucial properties such as ciliary motor characteristics have not been clearly elucidated. This project investigated a detailed ciliary behavior of swimming *paramecia* and their gravity sensing under varying viscosity.

The bacterial flagellar motor (BFM) in *Escherichia coli* (*E. coli*), a tiny rotary engine (~ 40 nm) that powers microorganisms, is one of the most complex and the largest biological motors. Its components such as a rotor, stators, a flexible hook, and filaments consist of ~ 25 different proteins. In particular, the complex of rotor and stators constitutes a torque generating unit. In the model bacterium *E. coli*, for example, the rotor is connected to a hook and surrounded by approximately 11 stators, and the estimated maximum torque when fully loaded is ~ 1260 pN·nm. However, much remains to be investigated, in particular, the torque generating mechanism of the BFM. In this study, we investigated the torque generating mechanism of the BFM in *E. coli* using innovative instrumentation, Magnetic Tweezers (MT).

SRP-7

THE CATALYTIC CHEMISTRY OF THE I-R3 DNA ENZYME THROUGH ION PROMOTED CLEAVAGE

Madison Pellerito
Monmouth University Department of Chemistry and Physics

Faculty Mentor: Dr. Jonathan Ouellet
Department of Chemistry and Physics

Funding Sources:
Monmouth University School of Science; Department of Chemistry and Physics

Abstract

Deoxyribozymes are synthetically engineered short ssDNAs that hydrolyze RNA. More recently, a small ssDNA enzyme was engineered to break the phosphodiester bonds of DNA, which are important for genetic storage. When the I-R3 DNA enzyme is annealed to its single-stranded DNA substrate, an asymmetrical bulge is formed. In the presence of Zn^{2+} under neutral pH, the substrate strand of this structure will be cleaved, resulting in a 5' and 3' product. At the discovery of the I-R3 DNA enzyme, Zn^{2+} promoted cleavage activity, while Cd^{2+}, Co^{2+}, Cu^{2+}, Ni^{2+}, Mn^{2+}, Ca^{2+}, and Mg^{2+} did not.

This project is designed to study the cleavage behaviors of the I-R3 DNA enzyme through substituting different metal ions for Zn^{2+} based on their similarities in atomic radii size to that of Zn^{2+}. The current hypothesis is that metal ions of similar atomic radii size to Zn^{2+} may promote the cleavage activity of the I-R3 DNA enzyme.

The chosen metal ions will be added by a syringe to a cuvette in a fluorometer containing 100 pmol DNA enzyme, 10 pmol DNA substrate with 2-aminopurine substitutions, 50 mM HEPES pH 7.05, and 1M NaCl. If the DNA enzyme's cleavage activity is promoted with the chosen metal ion, the fluorescence intensity of the sample will increase from the initial reading of the sample without the metal ion. Current experiments are being done to determine the optimal annealing process for the ssDNA enzyme and ssDNA substrate, such as testing overnight slow cooling in a heat block, and slow and fast cooling in a fluorometer.
Understanding the correlations between metal ions and cleavage of the I-R3 DNA enzyme would have a significant impact on the understanding of deoxyribozymes and their catalytic function. This research could also have further biological applications with targeting and cutting single-stranded viral DNA, such as parvoviruses.

SRP-8

PCR ASSEMBLY TECHNIQUE TO PRODUCE A PLASMID USED FOR RATIOMETRIC FLUORESCENCE MEASUREMENTS

Haniya Qureshi and Akriti Tandon
Monmouth University Department of Chemistry & Physics

Faculty Mentor: Dr. Jonathan Ouellet
Monmouth University Department of Chemistry & Physics

Funding Sources:
Monmouth University School of Science; Department of Chemistry & Physics

Abstract

In this project, several plasmids' parts are amplified using PCR to eventually create a brand-new plasmid using PCR assembly. The components of this larger pBR322 plasmid include the LactoseOperator, mCherry protein, Theophylline Riboswitch and Green Fluorescent Protein. LacO is able to regulate transcription, mCherry is a pink, fluorescent indicator protein. TheoRs regulates translation; for example, when the theophylline compound is present, translation with the ribosome in the bacteria occurs, inducing production and expression of GFP, while if the ligand is absent, the TheoRs is off and GFP is not expressed. Plasmid pBR322 contains the ampicillin resistance gene, tetracycline resistance gene and the origin of replication. In such a system, the mCherry is always expressed and GFP expression is dependent on TheoRs concentration.

Currently, correct conditions for the PCR parts are ongoing with troubleshooting, improving elongation times, annealing temperature, %DMSO. PCR products were examined by performing analysis on agarose gels. By utilizing Beer's Law, absorbances can be converted to concentrations, providing the amount of picomoles per microliter. When completing the PCR assembly, a certain amount of each of the inserts will be included in the tube.
The project will use ratiometric measurement to measure a K_D, which will be compared to the *in vitro* K_D of 0.7 μM. If the value of K_D is reproduced, it can be used to find the K_D in new aptamers of living bacteria.

DEPARTMENT OF COMPUTER SCIENCE
AND
SOFTWARE ENGINEERING

SRP-9

LIP SYNCHRONIZATION OF 2D ANIMATED CHARACTERS: A PRELIMINARY DATASET

Crosby Collins[1], Ethan Yung[2], Raymond Yung[3], William Judd[4], Dominick Del Bene[5], and Kelly Yuan[2]

University of Pennsylvania[1]; High Technology High School[2]; Freehold Borough High School[3]; University of Illinois Urbana-Champaign[4]; Monmouth University[5]

Faculty Mentor: Dr. Weihao Qu
Monmouth University Department of Computer Science and Software Engineering

Funding Sources:
Monmouth University School of Science; Department of Computer Science and Software Engineering

Abstract

AI lip-synchronization uses machine learning to match the lip movements of a subject in a video with a given audio file. This technology has the potential to create real-time talking virtual avatars, automatically match actors' lip movements to dubbed audio in different languages, and enable simultaneous translation and dubbing in video conferencing. Previous work in the field has focused on the synthesis of talking-head videos trained on human faces. While this research is promising for live-action media, there is a lack of research on lip sync for 2D animated characters, specifically Japanese animation-style characters.

This project is a preliminary step toward developing a machine-learning model capable of synchronizing the lips of animation characters to dubbed audio across a range of animation styles. Before attending to the unique challenges posed by automated lip sync in animation, the lack of animated video datasets intended for lip generation must be addressed. Canonical lip synchronization models are trained on curated clips of human speakers. This project aims to create a comparable dataset for animated videos.

Our AnimeSync2D dataset is derived from Anim400K, a large collection of anime video clips that requires pruning to be effective in the task of lip synthesis. To ensure consistency in clips, shot boundaries were made based on color histogram comparisons across the original video. We also discarded shots with multiple people in frame. Face detection was done using a local binary pattern-based method trained on anime faces for fast latency. Unique shots where a character is not talking and a monologue is taking place also needed to be accounted for. To verify clips only consisted of talking characters, we used a facial landmark detector to calculate if a character's lip would open when speech was occurring. Overall, AnimeSync2D will progress research in animation-based lip synthesis and other downstream tasks.

SRP-10

REINFORCEMENT LEARNING-BASED DELIVERY PATH OPTIMIZATION FOR HOSPITALS

Miriam Abecasis[1], Jason R. French[1], Kevin Yuan[2]

[1] Monmouth University
[2] University of Wisconsin-Madison

Faculty Advisor: Dr. Jiacun Wang
Department of Computer Science and Software Engineering

Funding Sources:
Monmouth University School of Science; Department of Computer Science and Software Engineering

Abstract

Reinforcement learning (RL) is a branch of machine learning that facilitates autonomous agents' interactions with their environments. During the last SRP, a Python program was developed in which an RL algorithm was employed and an autonomous agent was trained to navigate a virtual hospital. The agent's main task involved navigating the hospital environment and picking up medicine, and then dropping the medicine off at a terminal location. The agent received a numeric reward for every action which, after several iterations, enabled it to learn the optimal path through the environment. The program utilized a Q-learning algorithm, which uses Q-tables to map state-action pairs to determine which actions are optimal.

The goal for this iteration of the project was to expand on the Q-Learning algorithm by instead using a more complex approach. This was accomplished by creating a more expansive environment which represented a more realistic hospital and transitioning the Q-learning algorithm to a deep Q-learning (DQN) algorithm. Instead of using Q-tables, DQN algorithms use neural networks. Q-tables are discrete, and only work effectively for simple problems with a limited number of actions an agent can perform. Neural networks, on the other hand, are continuous, and can work more efficiently with large quantities of possible actions that an agent can perform. Realistically, an agent navigating a hospital would be capable of performing many actions in a non-discrete environment. Therefore, switching to a DQN in a continuous environment provides a more realistic way to simulate a real-world implementation.

The long-term goal of this project is to optimize the pickup and delivery of essential supplies and medications in hospitals, thus enhancing the efficiency of hospital operations and contributing to improved patient outcomes.